

INTRODUCTION OF AN INNOVATIVE TECHNOLOGICAL PROCESS IN THE GEAR GRINDING WORKSHOP AT ZMM NOVA ZAGORA

ВНЕДРЕНИЯ ИННОВАЦИОННОГО ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА НА ЗУБОШЛИФОВАЛЬНОМ УЧАСТКЕ ЗММ НОВА ЗАГОРА

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Abstract: The article studies the prerequisites for the introduction of process innovations at ZMM Nova Zagora JSC. The main principles of an original approach for decreasing the degree of discrete manufacturing by introducing an innovative technological process for mechanical machining of tooth gears are expounded. The results of its introduction in the gear grinding workshop are presented.

Keywords: TECHNOLOGICAL INNOVATIONS, UNIFICATION OF TECHNOLOGICAL PROCESSES, GROUP TECHNOLOGY, GEAR GRINDING

1. Introduction

The dominant factors on the world markets in the field of machine building are price, quality and flexibility. Nowadays the modern market situation also concerns the production of metal cutting machines, which more and more frequently makes manufacturers offer new variants or modifications of existing machines. A change in the character of production is observed when the product range expands and the series decreases.

The companies, manufacturing components and units, apply different approaches in order to adapt their organisational and production structure to fast adjustment when changing from one product to another. Process innovations are a good basis for optimisation of technological expenses, for the quality of the manufactured products and for the flexibility of the production process.

2. Prerequisites for the introduction of an innovative technological process

The production of tooth gear occupies a major share in the product structure of ZMM Nova Zagora JSC and it has the following technological profile:

- Wide product range – over 560 types;
- Primarily single and small series production – from 4 to 200 items;
- Wide scope of parameters – outside diameter from 30 to 500 mm, module from 1 to 15 mm;
- Average gear accuracy grade – 6.

Conventional methods and typical technological processes are applied in the gear manufacturing process. Gear grinding, which is carried out according to the generating method, is the finishing operation for the majority of them (over 60%).

The gear grinding workshop is organised according to the object-locked areas principle, preserving its operational specialisation. The average coefficient of the ratio of operations performed per workstation is $K_{op} = 11$ and the production flexibility coefficient is $K_{pf} = 0.91$. There are six gear grinding machines in the workshop dating from 1972 to 1987, which are outdated and have exhausted service life. The cutting conditions are low: feed rate – 1000 mm/min (for rough machining) and 300 mm/min (for finish machining). The time losses for changing the machine settings, for dressing and changing the tools, and the expenses for labour and maintenance of the technological equipment are considerable.

According to company data for 2014 gear grinding machining time amounts to 13% of the total gear manufacturing time and gear grinding cost constitutes 7% of the total cost.

The analysis of the company production programme for 2012-2014 (Fig. 1) shows:

- 61 types of tooth gears drop out of production and 154 new types are introduced;

- tooth gears with external diameter of up to 400 mm (over 98.7%) and with module of up to 4 mm (about 99%) predominate;
- over 80% of tooth gears are manufactured in series of up to 200 items, which amount to between 28.6% and 40.6% of all gears in terms of quantity;
- the range of different gears manufactured in series of up to 10 items has increased 1.5 times and the range of those manufactured in series of up to 100 items has decreased insignificantly while preserving the same quantities;
- the range of different gears manufactured in series of up to 500 items has decreased more than by half whereas the quantities have decreased over 1.5 times;
- the range of different gears and quantities of the remaining types of gear are relatively stable.

As seen from the production programme data and the manufacturing conditions the production of tooth gears in ZMM Nova Zagora JSC is characterised by dynamics as to range of different gears and series production, and a high degree of production flexibility. Economically justified adaptation of this type of production can be achieved by introducing new innovative highly effective technological solutions and up-to-date highly productive technological equipment.

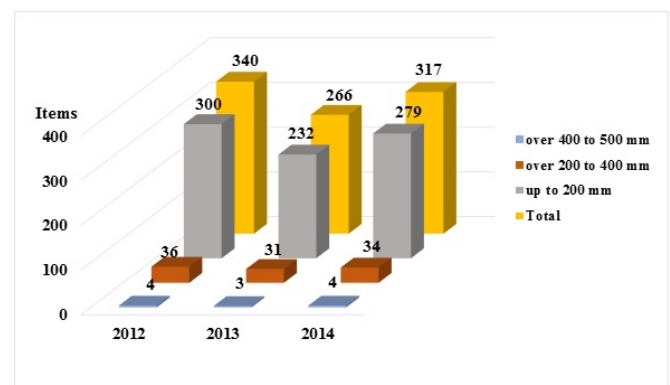


Fig. 1 Range and serial production of ground tooth gears

3. Innovative technological process

The main purpose of introducing an innovative technological process in the gear grinding workshop at ZMM Nova Zagora JSC is achieving optimal usage of the technological equipment and reducing technological expenses while guaranteeing stability of the gear grinding process, by target regulating the degree of production flexibility. A new approach to designing and implementing technological processes for machining tooth gears has been adopted in order to achieve this goal. The innovative approach is based on the principles of technology unification and group technologies [1, 2, 3, 4] and contains two main components:

- Introducing unified group technological processes taking into consideration the technological equipment in the gear grinding workshop.
- Development of engineering and technical tools for the implementation of a flexible gear grinding process guaranteeing optimal technological expenses.

The main differences between the existing conception and the innovative one amount to the organizational and technological structure of the preparation and implementation of production processes.

The innovation encompasses the current for 2014 317 types of tooth gears, whose individual technological processes (ITP) are systematized according to the type and sequence of the implemented technological operations. The tooth gears are grouped according to technological characteristics in 6 complex technological groups, for each one of which a complex tooth gear is created. Intelligent parametric 3D models are developed for complex tooth gears within the SolidWorks engineering design system. The group technological operations for machining tooth gears from each complex technological group (76 group technological operations for 317 tooth gears in total) are specified. The complex operational groups are formed by classifying the tooth gears from the complex technological groups by module. Twelve unified technological operations (UTO) are intended for them, each one of them with a defined unified setting for gear grinding machines.

The content of route and operational groups for each complex technological group is specified. Route groups comprise tooth gears, machined at different settings of the machines of one and the same group route technological process. Operational groups include tooth gears, whose technological operations are performed at the same unified settings of the machines.

The aggregate of group route technological processes of a complex technological group forms a unified group route technological process (UGRTP) for machining the tooth gears from this group. The developed structural variants of UGRTP for machining the 317 tooth gears are illustrated through the structure of UGRTP of one of the complex technological groups (Fig. 2). The abbreviations below the graphical images of this figure constitute accepted alphabetical codes for formal description of types of technological operations. This UGRTP comprises ITP of 9 types of tooth gears, divided in 4 route groups – Group D, Group E, Group J and Group I. The tooth gears from each group can be manufactured in one batch.

The sequence of UTO for machining the tooth gears from one operational group determines the group operational technological process for this group. The aggregate of the group operational technological processes for tooth gears from the same complex operational group form the unified group operational technological process (UGOTP) for this group. The approach of forming UGOTP is illustrated through the structure of technological processes for machining the tooth gears from Group D (Fig. 3).

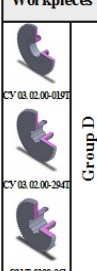











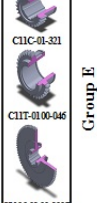


































Workpieces	Group technological operations													
	GTO1	GTO2	GTO3	GTO4	GTO5	GTO6	GTO7	GTO8	GTO9	GTO10	GTO11	GTO12	GTO13	GTO14
 Group D CY 03.02.00-019T CY 03.02.00-294T C11T-0100-061														
 Group E C11C-01-321 C11T-01-00-046 CY 03.02.00-299T														
 Group J C11T-01-00-039.1														
 Group I C11C-01-104 C11C-01-924														

Fig. 2 Structure of a unified group route technological process



































Workpieces	Unified technological operations										
	TRN	STML	GML	3KP	HTTR	SLT	ICGRD	BRCH	PBRCH	ECGRD	GGRD
											
											
											

Fig. 3 Structure of a unified group operational technological process

The effective realization of innovative solutions necessitated the restructuring of the gear grinding workshop which includes updating the machines with a new CNC gear grinding machine Niles ZE400/500.

4. Results of introducing an innovative technological process

The company policy envisages the process innovation should encompass the whole production range of tooth gears step by step. The results of introducing an innovative technological process for 30 types of pilot tooth gears, divided in 5 complex technological groups, are commented on in this report (Fig. 4). Eight unified settings of the Niles ZE400/500 gear grinding machine are specified for their machining.

Group names	Complex technological groups									
	Complex tooth gear	Typical tooth gears								
Group I										
Group II										
Group III										
Group IV										
Group V										

Fig. 4 Distribution of pilot tooth gears in complex technological groups

After comparing the data for machining pilot tooth gears before and after introducing the innovative technological process and the highly technological CNC gear grinding machine Niles ZE400/500 (Fig. 5), the following summary can be made:

- Automatic execution of the machining cycle, of monitoring and measuring operations, and intensified cutting modes with Niles ZE400/500 contribute to decreasing the total gear grinding time over two times (see Fig. 5a).
- The introduction of group technological processes and unified settings decreases the annual time for resetting Niles ZE400/500 over 2.8 times (see Fig. 5b), which amounts to 0.7% of the effective annual working time.
- After introducing the innovative approach, gear grinding cost price fell by 20% (see Fig 5c).

5. Conclusion

After introducing the innovative technological process and the gear grinding machine Niles ZE400/500 in the gear grinding workshop ZMM Nova Zagora JSC is expected to achieve the following positive results:

- Increasing the serial production and the production capacity through introducing unified group technological processes and decreasing the gear grinding resetting time.
- Decreasing the finished products cost price as a result of reducing the expenses for the technological preparation of the production and optimizing the production costs for gear grinding.
- Improving and guaranteeing stability of the finished products quality by also ensuring conditions for manufacturing tooth gears with up to 4 gear accuracy grade.
- Preserving and expanding the product range by ensuring a high degree of flexibility of the gear grinding process under the

conditions of a complex technological process – a wide product range and small series production.

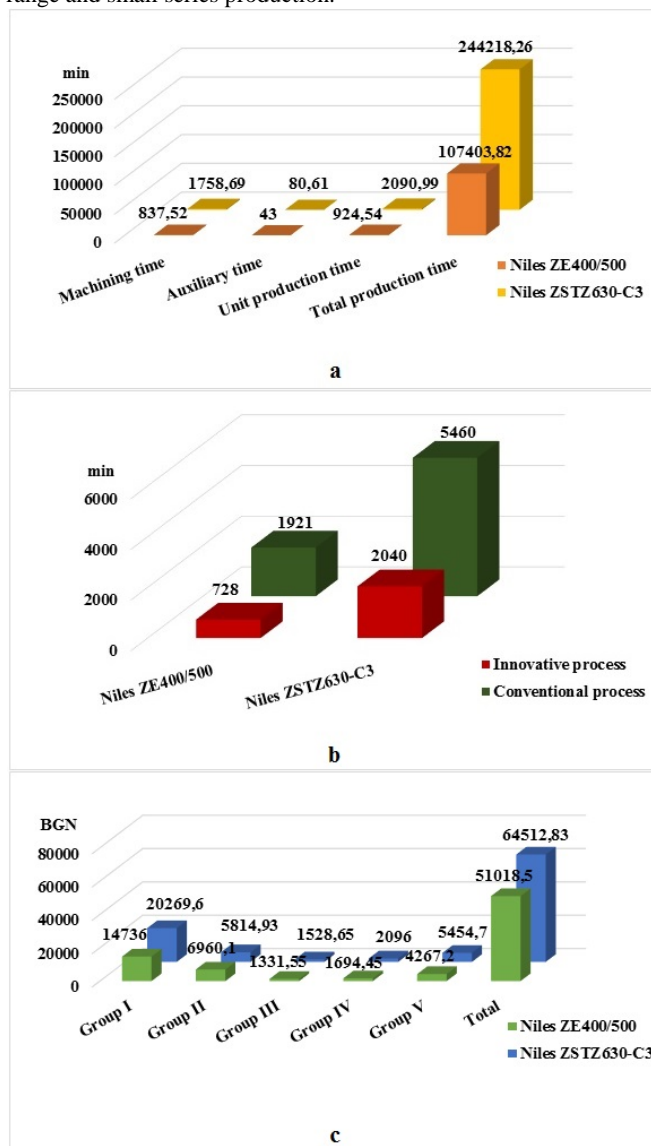


Fig. 5 Comparative analysis of production results before and after introducing the innovative technological process
a, b – production time; c – cost price;

- Increasing the degree of automation of the technological preparation and the production in the gear grinding workshop by introducing information technologies and computer technologies in design and production.
- Achieving maximum productivity in the gear grinding workshop under the conditions of a wide product range and small series production by optimizing the frequency of resetting the machines and the size of the batches.
- Improving the competitiveness and the market positions of the company.

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